Using the Raven Hydrological Modeling Framework to Support Climate Adaptation in Local Government-Managed Watersheds

INTRODUCTION

The Raven hydrological modeling framework is a software package for watershed modeling. It can be used to aid in understanding the hydrological behaviour of a watershed in light of changes in land cover, climate, and soil conditions. The framework's modular design makes it very flexible, allowing modelers to apply algorithms that accurately simulate conditions in the watershed in question and/or test a variety of possibilities for the future.

As a result of the current and future impacts of climate change, local governments in the Columbia Basin-Boundary region are facing uncertainty related to the future of the watersheds surrounding their communities. An accurate and easy-to-use watershed model could serve as an effective decision support tool for local government management of drinking water assets (including natural assets) or land use in watersheds. To test the value and utility of the Raven framework for local governments in this region, we undertook a pilot project for the City of Cranbrook. The City's drinking watersheds were modeled in order to develop a preliminary understanding of how projected climate changes and various wildfire scenarios could impact flow conditions.

PILOT RESULTS

Model development

The project team successfully built and calibrated a model that effectively simulated the Gold Creek watershed. It was not possible to model the Joseph Creek watershed due to questions about the discharge data available for that creek – the modeling process identified that either a large volume of water is being lost from the channel, or that there is an error in how the data are generated.

The project applied two wildfire scenarios (a disbursed burn of 30% of the watershed and a concentrated burn of 30% of the watershed) and two climate change scenarios (based on low and high global emissions).

Modeling results

The outputs of the modeling process indicate that landcover disturbance from wildfire could have an immediate increase on the magnitude of peak flows from Gold Creek but that the timing of flows is unlikely to change substantially. Given changes in temperature and precipitation as projected with climate change within approximately the next 60 years, it is possible that there will be a decrease in the magnitude of floods across the full range of frequencies; however, this finding should be re-evaluated if a weather generator that more accurately captures projected future climate variability is applied to the model. In addition, the timing of peak flows and return to low flows is projected to occur substantially earlier in the year.

Future adjustments or research

To support a more detailed understanding of the potential hydrological response of Gold Creek to changes in climate and land cover, further research and model calibration is required. In particular, the weather generator used to predict climate changes should be adjusted to incorporate a more accurate projection of changes in climatic variability.

A copy of the full Cranbrook report is available here.

APPLICABILITY OF RAVEN TO THE LOCAL GOVERNMENT CONTEXT

Decision support

The Raven framework offers valuable decision support to local governments who wish to better understand the following in the context of climate change:

- how various projected climate scenarios are likely to affect flow conditions;
- how various wildfire scenarios are likely to impact flow conditions; and/or
- how other types of land use change or forest disturbance (e.g., logging or interface fire risk reduction) are likely to impact flow conditions.

This information could help inform decisions related to flood risk management, infrastructure upgrades, land use planning/approvals, or natural asset management.

It is possible through the Raven framework to simultaneously model scenarios that test how multiple uncertain factors (e.g., climate change and wildfire) may interact to influence future conditions in the watershed; however, models perform best when the number of uncertain variables is limited. Introducing additional layers of uncertainty to the modeling process will reduce the accuracy of the outputs.

Project requirements

In order to build and calibrate a watershed model, the following data are required:

- At least 20 years of accurate daily discharge data from the watershed
- A digital elevation model for the watershed
- Land use data (e.g., vegetation resource inventory data or satellite imagery)
- At least 20 years of daily temperature and precipitation data from a station with a close climate relationship to the watershed in question. Where this does not exist, it is possible to use data from a gridded climate data generator.

The requirement for 20 years of high-quality discharge data in the watershed somewhat limits the utility of this model to Basin-Boundary local governments given the lack of long-term monitoring in many areas. While it is possible to use a proxy watershed to infer flow conditions, this approach adds an additional layer of uncertainty to the model.

A watershed model should be built and calibrated by modeling experts; however, local government staff, if trained, should be able to manipulate the calibrated model to test the impact of various climate and land cover scenarios. Training requires a few hours of staff time assuming existing background knowledge in GIS or coding.

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